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ROOF COVERINGS

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The builder of to-day realizes more and more the necessity of permanent construction. To obtain this end he must give careful consideration to the selection and application of those parts which are to protect the building and its contents from the action of the elements.

In the selection of materials, the elements of chief consideration are:

1. Resistance to Weather. The primary essential of roof coverings is that they successfully withstand the attacks of rain, wind, heat, cold, snow and ice.

The joints of the covering material should be so constructed as to permit of all expansion and contraction consequent upon variations of temperature. They also should not be retainers of water, since this on freezing would cause their rupture.

The roofing material should not absorb too much moisture for if frozen in this condition, it would mean its failure.

To satisfy all these conditions not only must the surface be impervious but the joints must be constructed in such a way as to prevent the failure of the covering at its connections.

2. Strength and Rigidity. In addition to acting as a covering and enclosure, the roofing material should be capable of bearing its part of the imposed loads and transfer them by arch or bending action to the trusses or walls. Under ordinary conditions the covering should be strong enough to withstand without excessive deflection, the wind pressure, snow load and any accidental liveload which it may from time to time have to endure. The wind load on roofs varies for different pitches and with the amount of exposure of the roof. The snow load depends upon the latitude of the place where the building is located, the pitch of roof, and to a certain extent on the kind of covering.

In addition to carrying the imposed loads the covering should, if necessary, be capable of contributing to the lateral stiffness of the building.

The connection of the covering to the purlins or rafters should possess sufficient resistance to prevent its bodily displacement by the wind and such other qualities of resistance as the conditions may necessitate.

3. Fireproof. While resistance to fire is a requirement which varies somewhat with the character of the buliding and its location, the importance of it generally may be more forcibly impressed by the treatment under this heading. Moreover, nearly all roofs are more or less subjected to the action of fire and the use of a fire resisting roof on any building will affect a saving in the matter of insurance.

A large percentage of the enormous fire losses on this continent are due to exposure, that is the fire is spread from one building to another. One of the most important factors contributing to the spread of such fires is the combustible roof. The report of the National Board of Fire Underwriters on the San Francisco conflagration emphasized strongly "the importance of fire-resisting roofs" and similar comments may be noted in reports on other conflagration. As a result, the use of fire resisting roofs in the central parts of many cities is now obligatory.

In designing a standard to afford a means of classifying roof coverings independently of the roof structure upon which they are applied and according to their fire resisting value, the National Fire Protection Association has considered the following (1) inflammability of the roof covering; (2) fire retardent properties, (a) ability to resist spread of fire on the surface, (b) protection afforded the roof structure against exposure to high temperatures; (3) Blanketing effect upon fires within buildings; (4) Flying brand hazard of the covering.

Outside of the ordinary dangers from fire some roofs possess an advantage over others in the case of lightning. "Roofs constructed of good conductors of electricity do not require any other protection against lightning as they serve to scatter the currents and thus dissipate their energies without danger of actual ignition."

4. Durability. A good roof should last without repair as long as the building it covers stands without repair. It should wear well, resisting abrasion from weather. Thoroughness in the preparation of the flashings, around openings and other parts subjected to special wear is of vital importance. The thickness of material used at these points should be such as to provide sufficient resistance.

5. Least Expense. The roof covering chosen for a certain building should be that which in the ultimate analysis gives the greatest service for the longest time at the least expenditure, including original cost and maintenance. Herein lies the necessity of careful selection. The first cost may be low and the maintenance cost high. "The annoyance and indirect expense occasioned by leaky and short lived roofs is rarely compensated for, by any possible saving in first cost. It is the duty of the builder to balance the factors of first cost and maintenance computed on the probable life and service of the structure.

Character of the Building. It is obvious that no one roofing material will be satisfactory to cover all classes of buildings. Attention must be paid to the uses for which the structure is intended and to its temporary or permanent use.

Architectural and aesthetic considerations will have considerable weight in some cases. The roofing of monumental structures and also of small dwellings have considerable effect on the appearance of the building. The construction of the roof has a marked influence on the temperature within the building. Some coverings conduct heat very rapidly and some insulating method must be used.

"The radiation from roofs is without doubt a very serious problem in the designing of any building, especially of a concrete building."

Akin to the prevention of radiation is that of insulating against condensation. In some cases it is of utmost importance that no moisture drip upon machines of various kinds, their products, or the operators. Again, if under surface of the roof be of metallic nature, the formation of moisture on it may cause its rapid deterioration.

There are certain methods of insulating roofs which necessarily add to the expenditure for the covering.

In fireproof buildings special consideration should be given to the roof. To confine internal fire the roof must act as a perfect barrier to the outbusrt of the flame, for when it is once broken through, the intensity of the fire is rapidly increased by the resulting draught and suction. In buildings as ordinarily constructed, the under surface of the roof will receive a greater concentration of heat than any other surface of the structure.

Roof Pitch and Framing

Some roofing materials may be laid on any pitch except flat ones while others are limited in use to nearly flat surfaces. It is highly important that the choice of covering be adapted to the pitch of the roof or vice versa. The lack of this adaptation is a prolific cause of leaky roofs. The selection of a certain pitch limits to a certain extent the number of possible materials that may be applied to it and any consequent effect on expenditure must be borne as a result.

Location and atmospheric conditions. The type of roof to be used is very often settled by the location of the building with reference to the source of supply and the familiarity of the artisans with the material in hand. In this case the costs of securing and applying the material are the deciding factors.

Materials which are affected by corrosive gases should not be used without protection where they would be subjected to the action of these gases. Unusual climatic conditions may subject the covering to severe tests and hence should receive careful consideration.

If the building be so located that the walls of adjacent buildings extend higher than the roof to be constructed, the possibility of falling walls or debris should be considered. The Baltimore conflagration showed the necessity of this consideration.

Materials of Composition and Their Use

There are a large number of materials that are employed in the composition of roof coverings both singly and in combinations, and there is probably no roof made out of good materials in a workmanlike manner which does not find a satisfactory field for its use.

In the following discussion under the heading of the respective materials commonly employed in coverings, their use, application and characteristics will be briefly considered.

Wood

(a) Shingles—Long service has shown wooden shingles to have many good qualities for roofing purposes. However, the growing scarcity of good material for their manufacture is making it difficult to secure those of good quality. In some localities they can still be obtained but their cost has advanced very rapidly.

The durability of shingles is sometimes increased by dipping them in linseed oil or creosote. Efforts to do this by painting after laying have been made. It is true paint somewhat protects the surface of the shingle from cracking and warping, but it encourages decay below by closing the pores of the wood and preventing quick drying after exposure to rain or snow.

The chief disadvantage of shingles is their ignitability. In this connection the report of the National Fire Protection Association comments as follows:—"Wooden shingles are the principal American conflagration breeders."

On account of the fire hazard of this roofing material their use in central parts of many cities is prohibited. In other parts the chief factors in their selection are their low cost and adaptability to small and isolated buildings.

(b) Sheathing—Of late the chief use of wood in roofs has been in the body of the covering or as a sheathing material. Being very adaptable, it is employed to suit many requirements.

Sheathing is usually made of a single thickness of planks, 1 to 3 inches thick laid close together. Matched and dressed lumber is used under all waterproofing materials except shingles and it should be covered with some impervious material under metal, slate and tiles. The method of applying depends on the roof frame work and whether the space directly under the roof is to be occupied or visible or not. When the conditions of loading and span are known the thickness required to carry the loads without excess deflection can be determined from fundamental principles or by use of a simplified formula such as is given by Ricker.

The matter of deflection should receive careful consideration because not only is excessive springing unsightly, but it generally means interfering with the stability of the waterproofing material.

The following table gives the safe load in pounds per square foot for spruce plank of various spans and thickness for limited deflections.

Load per sq. ft. superficial	Span in feet 4	5	6	7	8
30	0.9	1.2	1.4	1.7	1.9
40	1.1	1.4	1.6	1.9	2.2
50	1.2	1.5	1.8	2.1	2.4

For Yellow Pine take 9-10 of thickness given above.

The inflammability of the material prevents its use in fireproof buildings. "The burning of wooden roof boards alone has proved sufficient heat to cause the collapse of steel roof trusses."

Attempts have been made to use fireproof wood as a sheathing material. The igniting point of the wood is raised slightly by impregnating its fibre with chemical compounds of which chloride of zinc, tungstate and silicate of soda are the most common. However, by this treatment the strength of the wood is sometimes affected. It is made more difficult to work with and the increased cost as estimated by Woolson is from $35 to $65 per thousand feet. Moreover, the presence of any perceptible amount of moisture, which is very likely to occur on the sheathing, induces the chemicals to have a corrosive action on metallic materials with which the sheathing may have connection.

Slate

Slates are manufactured in various sizes, shapes and colors, and have a wide application. The best quality of slate has a hard surface, a bright lustre, and when struck with the knuckles has a clear ring. Softer slates give a dull sound when struck, absorb water and hence are liable to break in frosty weather and the nail holes wear, causing the slates to loosen. The color of the slate does not appear to indicate the quality.

The chief merit of slates is their durability. They are fireproof as far as the flying brand is concerned at least, and do not collect dust or dirt.

The various colors and sizes can be utilized to produce good architectural effects. The largest size usually means the cheaper roof, but the smaller ones give the best appearance.

The main disadvantages to slate are its tendency to crack when walked upon or subjected to excessive heat, its conductance of heat and cold, its weight and expense. The last mentioned is usually the most important of these.

Slates may be laid directly on boards, battens, or on purlins. The punching of holes for fastening should be carefully done and copper wire nails should be used, for fastening. The lap is a very important part of slating and should be selected to suit the gradient of the roof. The standard lap for suitable pitches for slate roofs is three inches.

Clay Tiles

Waterproof roofing tile is made in a great variety of shapes and colors. Those of good quality are substantial and fireproof, require no painting and are non-conductors of heat and electricity. They should be well burned and be so made that they will not absorb moisture. Semi-vitrified or glazed tiles are the most durable and impervious. Glazing consists of giving the exterior surface a coating which at the temperature required for burning is converted into a glass like mass. In addition to rendering the tile more impervious, it serves to decorate it. A combination of ornamental shapes and colors can be used to present a more pleasing appearance than can be secured with other coverings.

There are two general types of tiles, flat and interlocking, the former being laid in cement and sheathing, while the latter frequently is laid directly on purlins. Of these two kinds, those which interlock are considered to give the most satisfactory roof from a practical standpoint.

Glass tiles are made in the same shape and size as the usual ones and can be used where skylight is desired without breaking the uniformity of the roof surface.

Tile roofs are costly not only in regard to the tiles but also in regard to to the additional strength required in the supporting trusses or frame work by reason of their weight. However, tiles are becoming much cheaper and a better grade is being produced, so that an increase in their use may be anticipated.

Non-waterproof hollow burnt clay blocks or tiles are sometimes used as a base for some waterproofing material.

A kind of hollow book tile (so called because of their shape) is used. They are supported by inverted tees set as rafters, embedded in mortar between the tiles. They are heavy and expensive but give a good type of fireproof construction.

In addition to the above uses of clay tile, those of the ordinary soft clay variety are sometimes used in insulating roofs. They are hollow, two or three inches thick, and assist in giving a very good type of insulation.

Again, ordinary clay tiles are used as a protection to what is called built-up roofs. They do this to good effect, affording a high resistance to fire.

Metallic Materials

In this discussion metallic roofing will be classified and treated according to the metal which forms the base or body of the roofing sheet. It may or may not have a protective coating or some other metal or substance. (a) Iron or steel is an excellent material for using as a base in the manufacture of roofing sheets in as much as it has in itself nearly all the properties required for roofing material. It is corrodible and must be protected or its deterioration will be rapid. However, it should be borne in mind that the qualtiy of the iron or steel used in the manufacture has considerable to do with the longevity of the sheet. If durability is to be attained, the base metal should be free from those properties which accelerate corrosion.

The nature of the protective coating used gives use to four distinct types of sheets.

I. **Painted black sheets,** as the name indicates, are made up as black sheets of steel covered with a coating of paint before leaving the mill.

II. **Galvanized sheets** are made by passing thoroughly cleaned black sheets through molten zinc. The surfaces are covered with an adherent coating of zinc which excludes moisture from the iron. Since the corrodibility of zinc is low, the life of such a sheet is considerably lengthened. This process makes the sheets heavier by about one third of a pound per square foot and adds from 30 to 40 per cent to the first cost of the material.

Galvanized, painted or black sheets unpainted are made in standard sizes or gages in various forms.

The most practical form is that of corrugated iron which for most permanent use, although more expensive, should be made from muck bar iron. The corrugating is done to give the sheets longitudinal strength and incidentally improve the appearance of the sheets. The smaller corrugations are more pleasing to the eye, while the larger ones give greater stiffness to the sheet. The additional strength imparted to the sheets by the corrugations makes it possible to use this form without any underlying sheathing or support except the purlins or rafters. The following table which gives the safe and crippling loads in pounds per square foot for different gauges on different spans shows the strength of these sheets.

Gage	SAFE LOAD Span in feet				CRIPPLING LOAD Span in feet			
	3	4	5	6	3	4	5	6
26	31	23	18	16	69	52	41	24
24	37	28	22	19	84	63	51	42
22	48	36	29	24	107	80	64	54
20	59	44	36	30	134	100	80	67

Galvanizing seems to be the most satisfactory preservative for this form of metallic roofing. It should be applied to the sheets after corrugating so that the process of stamping will not injure the coating. When the corrugated iron is not galvanized it should receive two coats of iron ore paint on both sides before laying.

Plain sheets, roll roofing, V crimped and metal shingles are all forms of sheet metal which differ mainly in the form of application. The V crimped forms and plain sheets can be laid without sheathing, are easily applied, and give one of the cheapest coverings to be had. The other forms are made in a variety of styles and patterns, some of which present a very attractive appearance. All these steel forms of roofing can be obtained plain or galvanized in standard sizes. They are not so durable as iron sheets and hence require more frequent painting.

III. **Terne plate** is made by passing steel plates through a molten terne mixture. This mixture is an alloy of tin and lead in varying proportions, the most common mixture being 27% tin and 73% lead.

IV. **Tin plate** is similar to terne plate. Sheets of light iron or steel are coated with tin and passed between adjustable rollers which regulate the thickness of the coating. In both cases the finished sheets look alike but those having the thickest coating are the most durable and most expensive. The extra cost of a good plate is in the coating, and coating means protection of the plate.

Since pure or commercially pure tin is expensive and difficult to obtain, the tendency of manufacturers of tin and terne plates has been to skimp the coating of these plates. The result of having a very thin coating is that they do not give good satisfaction. The life of the sheets is not long and they require frequent painting, consequently their maintenance cost is high.

The question of the proper paint to use is a very important one since it has definitely been proven by recent investigations that some paints have an injurious action upon tin roofs, notably the graphite paints and those containing tar, pitch and similar bituminous substances.

The National Association of Sheet Metal Workers specify the use of pure metallic brown iron oxide or Venetian red as a pigment, mixed with pure linseed oil.

In general, metallic roofing materials of iron and steel have many good points in favor of their use. They are light yet strong enough as applied in most cases, and they possess sufficient resistance to fire to suit many buildings, are lightning proof and are easily applied.

Against these factors is their unpleasant connection with lack of durability. Not only must they be protected by some coating when first laid, but at frequent intervals during their life, the frequency depending on the material itself and the atmospheric conditions. That sheet metal is actively attacked by soot and smoke is shown by the tests recently conducted by the Industrial Research Department of the University of Pittsburg. The results indicate that painting must be done about twice as often as when the materials are not subjected to the action of smoke, etc.

Iron or steel is unsuitable for use in proximity to industrial plants which produce destructvie fumes or gases as the thin metal is quickly destroyed by corrosion and leaks develop.

Another disadvantage of iron and steel roofing sheets as ordinarily applied, is their transmission of heat and cold. Metal roofed buildings are harder to heat in winter, and in summer are uncomfortably warm.

When condensation is likely to occur to even a small extent, corrosion has another chance to do its work on the underside of the sheets. A fairly cheap method of insulation to prevent condensation may be applied, by placing a layer of tar paper immediately underneath the metal roofing and a layer of asbestos paper underneath the tar paper, the whole being supported by wire netting.

(b) Copper is the most durable metal that may be used for roofing. It is light and strong and weathers a fine tone. However, its high cost prevents its use on any but expensive or monumental buildings. It is laid on wooden sheathing in flat sheets and provision is made for the small amount of expansion and contraction that is necessary. Its heat conducting properties require it to be well insulated.

(c) Lead, the excellent and probably most durable roof covering used in England, is not suitable for this climate, the extremes of heat and cold causing too much expansion and contraction in the material.

(d) Zinc is used extensively as a roofing material in Europe. Its properties of strength and durability are probably more balanced than those of any other material. However, it has a high coefficient of expansion and failure to use it extensively on this continent is probably due to this and the difficulty of getting good material.

Reinforced Concrete

The use of concrete in coverings may be divided into two classes.

(a) Reinforced concrete plates (sometimes called tiles) or slabs, are moulded at a factory, delivered at the building and attached to the framing as a covering.

The tiles or plates are made in standard sizes which may be laid without sheathing. They interlock and are rendered impervious by being made dense and treated with a water proofing compound. The reinforcing of expanded metal gives them considerable strength and allows a purlin spacing of about four feet. Their cost, compared to other fireproof roofs is quite low.

Slabs are made in various thicknesses and lengths to suit the distance between rafters or purlins. As the lengths increase considerable provision must be made for expansion and contraction. This necessitates open joints which must be protected from the penetration of water. Moreover, the concrete itself must be made waterproof. Hence, the general practice is to lay some of the ordinary roofing materials over these slabs to keep out water, etc.

(b) Concrete roofs may be monolithic in construction. In this method the covering is made by spreading concrete either on reinforcing, supported by temporary wood forms or on some kind of self supporting expanded metal which requires no forms.

There is a great variety of reinforcing systems and the variety widens the type of monolithic construction, so that it is applicable to all forms of roofs from simple peaked to arched roofs and domes of elaborate composition.

When forms are used, any of the ordinary reinforcing may be employed. The thickness of slab depends upon the span. It is very desirable to have this thickness and consequently the dead weight of the slab of minimum value. For ordinary roofs a thickness of greater than 3 inches should not be used and this thickness according to Tyrrell, when properly reinforced, is strong enough for lengths up to 8 feet."

The use of combination forms and reinforcing is particularly well adapted to the construction of roof slabs. The reinforcing gives the slabs ample strength to carry the loads to which roofs are subjected and at the same time keeps down the thickness and consequently the dead weight of the roof.

These light concrete slabs not only make the amount of concrete required less but also permit the use of a lighter frame than other slabs and aid in lessening the disadvantage of weight that concrete roofs have.

In this construction the concrete does not surround and grip the metal. The only protection given to the under side of the reinforcement is a coat of plaster. This should be applied very carefully and given plenty of time to set or it may soon fall off. Intermediate supports to the reinforcement in case of long spans are necessary to bear the additional weight when the concrete has been placed, due to its being wet.

Monolithic concrete construction as compared to the other method has the objection to its use of the dripping from the wet concrete which sometimes makes it impossible to carry on other work in the building. Moreover, it is necessary to wait until the concrete has set.

Concrete roofs in general are durable, fireproof in the reinforcing is properly protected, and can be devised to give any desired amount of strength at the expense of increase in dead weight. If the great disadvantage of dead weight is not objectionable, concrete may be used for many buildings.

One objection to the use of concrete roofs on some buildings in Northern latitudes is the necessity for insulation to prevent condensation and heat radiation. Generally speaking, concrete is known as a poor conductor of heat but when compared with wood, especially in the case of thin construction such as is ordinarily employed in roof slabs of concrete, it is a relatively good conductor of heat and cold.

In winter uninsulated concrete roofs radiate heat rapidly and much more heat may be required in the building, or if warm moist air strikes it, condensation takes place on the lower surface of the slab and drops to the floor below. If this is objectionable, a means of prevention must be devised.

There are certain methods of insulating which in combination with adequate ventilation will prevent condensation and heat radiation.

There are seven types of insulation. (1) Roofing felts and quilts; (2) Cinder fill (with cement finish upon which the roofing is laid); (3) Cinder concrete fill (covered with roofing); (4) Hollow Tile (with mortar top coat upon which roofing is laid); (5) Combination hollow tile and cinder fill; (6) Double concrete roof (light concrete slab above main concrete roof); (7) Suspended ceilings.

In deciding upon the type of insulation to be used for any particular building it is necessary to study the conditions and requirements for that building. As both cost and weight are very important factors, the problem resolves itself mainly into that of finding a type of insulation which will be economical for the building considered. It would be a distinct waste to provide a type of insulation which would absolutely prevent radiation and condensation if a small amount of this was not objectionable.

Fibre and Materials Necessary for Its Use

Fibrous roofings may be divided into two classes.

(I) Built-up roofs. (II) Ready roofings.

Among these two general types there are many varieties which generally take their name from the kind of protective coating or waterproofing compound used for the fibre. While many materials are in the composition of both of the above types, the methods in which they are employed are quite different.

Built-up roofs, as the name indicates are made from various materials directly on the roof. They consist of from three to six layers of saturated felt laid on the roof, cemented together and coated with some kind of pitch and protected by slag, gravel, tile, or cinders embedded in the coating.

There are two kinds of pitch used for coating and cementing which give use to two types of built-up roofs, (1) Tar. (II) Asphalt.

Coal tar pitch from the distillation of bituminous coal is considered the best of the tars for roofing use. It contains some water, various impurities and free carbon, which after the water has been removed, is ordinarily from 5% to 35% of the total. The percentage varies with the method of manufacture and the coal used.

Free carbon is generally considered to be a valuable adjunct to roofing tars as it renders the material less affected by changes in temperature and it does not interfere with the saturating power of the felt.

Commenting on the matter of tars, the report of the A. R. and M. W. A. states—The best practice allows the use of nothing but "straight run" pitch.

Asphalts as found naturally are not suitable, even after the impurities are removed, being too hard and brittle. This is ordinarily remedied by softening or fluxing with various oils.

The fluxes should be sufficiently staple to insure against too rapid hardening of the fluxed asphalt. They should be free from deleterious constituents and should be of such character that they will combine with the asphalt to be fluxed so as to make a homogeneous and perfect solution. Poor fluxing hastens the loss of the elasticity and bending power of the compounds and with age allows them to become brittle and hard.

With skill in compounding, based on a thorough working knowledge of the materials used, asphaltic compounds can be prepared of natural asphalt and oil residuals with valuable qualities for roofing purposes.

A brief comparison of these two bituminous roofing materials might here be made.

Both can easily suffer from adulteration and poor preparation, but the asphalt seems to be more liable to this. From the chemist's view point asphalt is the safer material because it is less subject to changes when exposed to weather. However, the use of some oils for fluxing may make the asphalt more liable to internal changes. The coal tar pitch is cheaper, can be depended on for better results, and hence is more extensively used.

Felts

The felts used in built up roofs simply constitute a medium for holding the pitch material in place. Nearly all felts are made of rag stock and should have a certain amount of wool to give them saturating power. In using asphalt absorbent power is the main thing desired, while in using coal tar pitch, this quality is not so necessary. Very good results are obtained by using about five thicknesses of felt if the other materials are up to the mark. They are used in various proportions to get different results and to meet variations in the materials used.

Top Finish or Protective Coating.—A coating of some material is necessary to hold the top mopping of pitch in place, to protect it from the sun and from the action of the elements, and to give the covering some fire resisting value. Gravel, slag or crushed stone is commonly used for this purpose. It should not be too coarse or too fine or contain sand or dirt, to give the best results. Where the roof is to be subjected to wear, high fire resistance is required; and where the character of the construction warrants the expense, flat tiles or brick should be used.

As the materials used for cementing and coating will melt and run under the heat of the sun, the use of this type of covering is limited to flat or nearly flat surfaces. If used for steep slopes greater thickness of materials is required and they consequently necessitate greater expense.

Skilled workmen are necessary for the application of these roofs, and as the chances of poor workmanship are many, thorough inspection is required.

Ready Roofings

There are innumerable prepared or ready roofings which ordinarily are obtained in rolls with the cement and nails necessary to apply them. They vary from a very light felt with the cheapest possible saturant and enough sand or soapstone coating to prevent sticking in the rolls, to a sheet so heavy, that it cannot be rolled, built up of heavy felts and strengthening materials and saturated and protected also by carefully prepared compounds, and possibly protected also by a coating of crushed stone. Their durabilities and fire resisting values vary to as great a degree.

Prepared roofings may be divided into two general classes: (1) stone surfaced; (2) smooth surfaced.

The stone surfaced are to a certain extent an adaptation of the built-up roof. The protective coating must be of materials uniform in size. The amount that can be used is limited to the amount that can be rolled or that can be held on a certain pitch of roof.

The smooth surfaced roofings are usually coated with some finely divided material to prevent sticking in the roll. This must be stable and not easily effected by changes of temperature. Blown oils are frequently used for this purpose. To get the best life frequent recoating or painting is necessary.

Asbestos, magnesia, asphalt rubber, felt or some similar material, forms the basis of both these types. Many of the roofings made from these materials make excellent coverings. They can be placed quickly by unskilled labor and on almost any slope of roof.

They are of value for small and isolated buildings and for temporary structures where a roof of long life is not necessary. They are weak in that with narrow lap and a large part of the roof covered with but one layer of material a single defect can cause a leak. Another chance for trouble is their tendency to stretch and wrinkle and the difficulty of laying them absolutely tight and flat.

In making selections the reliability of the manufacturers, service tests, and cost should be the governing factors. To depend on guarantees does not give satisfactory results.

Miscellaneous Fibrous Products

(1) Sheathing paper is manufactured by impregnating straw, wood pulp or mineral fibre with hydrocarbons or some cementing compound. It is used under many of the common roofing materials to assist in keeping out moisture, heat, cold, wind, etc., and in some cases to assist in preventing radiation and condensation. Good paper should be tough, impenetrable by air or water, of uniform quality and be clean to handle.

(II) Insulating quilts are of the same general composition but are much heavier. They usually consist of two plies with some fibrous material between the plies. These quilts are laid between the sheathing and the waterproofinig materials. They are not positive insulators but afford a cheap means of fulfilling the requirements of insulation for some cases.

(III) Asbestos sheathing and protective metal are products which in properties somewhat resemble corrugated iron. They are made up of cement, asbestos and some reinforcing mesh or sheet metal. The product has considerable fire resistant value, is durable and waterproof and has in its composition materials which are generally considered necessary to give wood characteristics to a material. They are light and strong, have a high first cost, but no maintenance expense. The materials are laid in the same way as corrugated iron.

(IV) Asbestos shingles are made of asbestos and cement by means of a press. The materials used give them some of the characteristics of wooden shingles and make them durable and fireproof. They seem to have most of the qualities necessary for a roofing material and appear to render good service. They have a high first cost, but no maintenance.

(V) General Notes on Roof Coverings. (a) The following table compiled from various sources gives the latest desirable pitch for different roofing materials:

Material	Rise in 12 in.
Wooden Shingles	6 in.
Slates, ordinary	6 in.
Clay Tiles (interlocking pattern)	7 in.
Clay Tiles (ordinary)	3½ in.

Corrugated Iron	4½ in.
The Crimped Steel	2
Steel Roll Roofing	2
Tin and Terne Plate	1
Copper	1½
Lead and Zinc	1
Concrete	Flat
Built-up Roof—	
Tar and Gravel	½
Asphalt	½
Ready Roofing	1
Asbestos Shingles	3

(b) Weights. The following table from Tyrrell's Mill Buildings gives the total loads per square foot of roof surface for different kinds of roofing.

Roof Covering	Lbs. per sq. ft.
Corrugated iron, unboarded	8 to 10
Corrugated iron, on boards	10 to 12
Slate on laths	12 to 15
Slate on 1½ in. boards	15 to 18
Tar and gravel	10 to 12
Shingles on laths	8 to 10
Tile on plank	20 to 30
Tile laid in mortar	25 to 35
Sheet metal on boards	7 to 9
3 in. reinforced concrete	40 to 45

(c) Costs. The great variety of roofing materials and different qualities of these makes possible wide differences in the cost of a covering for a building. Moreover, the requirements of the building and the extent of the fulfilment of these have direct effects on the costs. Consequently any cost data that might be given would only be approximate and this can be obtained in cost data handbooks.

A general but brief account of the cost of coverings will be given.

Some of the various prepared roofings are the cheapest having low first cost and being cheaply laid. Other kinds in order of cost are wood shingles, tar and gravel, corrugated iron, sheet steel, metal shingles, slate, tin plate, asbestos shingles and tile.

For the base of the covering, wood is, of course, the cheapest. The other materials in order of cost are concrete, asbestos, board and tile.

C. E. B. Corbould, B.A. Sc., '14, is in the Engineering Department of the Hydrographic Survey Branch, Department of Interior, at Kamloops, B.C.

In the July issue we erred in stating that Mr. A. W. J. Stewart, '08, was general manager of the Toronto Hydro-Electric System. Mr. Stewart holds the position of assistant engineer of the Hydro-Electric system.

"A DESIGN OF A POWER PLANT"

F. ALPORT, B.A.Sc., '06

PART I—PRELIMINARY CONSIDERATIONS

In the development of a water power, the engineer must do more than merely design and construct the power plant. The stability of the dam, size and strength of penstock or flume, choice of turbines and generators, and the design of the power house in which the turbines and generators are placed, are really a secondary consideration. The adequacy of the supply of water, head and power available at different seasons, conditions affecting these, and the advisability of the investment, occupy the premier position. A knowledge of these most important factors is more essential than a knowledge of design and construction, for a competent designer may be hired any day for $100 or $150 per month. Therefore, to ensure success, a study of the entire project becomes necessary.

Unfortunately, at the present time, the engineer is very greatly handicapped when called upon to consider the development of a water power in Canada. Not enough data is known on which to base calculations, so in every case many assumptions and deductions must be made. For instance the water available for power depends upon the amount that runs off of the watershed, the run-off depends on the precipitation, so a knowledge of the annual precipitation over a term of years should be known. At the present time this is unknown in the majority of cases and must be estimated. However, the Hydro Electric Power Commission for Ontario, and the Commission of Conservation for the remainder of Canada, have started to collect data relative to the rainfall, and to meter the rivers, establishing the relation between precipitation and flow on each watershed, so that, in the future, we will have to do much less estimating.

When called on to look into the possibilities for power development, the first step is to examine the various falls on the river, in order to decide, where there is any choice in the matter, which will give the required power most economically. This, in the majority of cases, can be decided by merely seeing the various falls. If there is sufficient water in the river for the required amount of power, at any two or more possible selections, the one that can be developed with the least expensive head works and shortest flume, will naturally be the choice. Proximity to the market is also an important factor, but is not likely to be the predominating one, for power can be transmitted very efficiently, and in many cases it is possible to bring the market to the power.

If it is not possible to decide the point of development by looking over the possibilities, a rough survey can be made by means of the hand level. The heads can be determined with this and the flow can also be found out by using a rod float. This will give sufficient data to definitely decide which fall is the better for the purpose required.

The point of development having been decided on, an accurate topographical survey must be made. The topography is taken and plotted in two foot contours and accurate notes made of the kind of material, whether rock, clay, sand, etc. If necessary, borings must be made to ascertain the depth of the strata overlying the rock. This can be very easily done by means of an ordinary auger welded to a length of inch or inch and a half iron pipe. Soundings must be made on regular cross sections of the river so that the contours can be plotted over the river bed. The elevation of the water at the top and bottom of the fall must be very carefully obtained, as well as the elevation of the high and low water. Frequently the inhabitants of the vicinity can give much valuable information as to the high and low water elevations and, although this information is not altogether dependable, it is often the best that is available.

The stream must also be carefully metered. If possible, it should be metered at high and low water, but this generally cannot be done, on account of the time that would elapse between meterings, so the engineer must estimate the high and low water flow. This is generally done by plotting a cross section of the river, finding the areas of the water at high and low water elevations and assuming that the velocity is constant for all seasons. It is advisable to add ten per cent. to the high water and deduct it from the low water flow, to give a good margin of safety.

The extent of the watershed and its physical characteristics, must be known. If no other information is available, it is necessary for the engineer to travel through it and make a rough survey of it. This will never be necessary in Ontario for maps of the whole Province can be had that give sufficient information. From them the area of land and lakes in each watershed may be computed. The physical characteristics of the watershed, such as soil, forest land, cleared land, cultivated land and prairie land, affect the annual run off and a knowledge of the extent of each is necessary. This information would not be necessary if the gauging of the stream and the annual precipitation were known over a term of years, but in nearly every case no such information can be had, so the engineer must resort to estimating.

The description of the river follows naturally that of the watershed and also must be known. The velocity of water is affected by the condition of the banks, the straightness, depth, character of the river bed, fall and number of rapids. This information is interesting but really does not affect the proposition enough to make it an important factor.

The discharge of the river, along with the head obtainable, really are the predominating factors in considering plans for the development of any water power. The head is obtained by the survey, but not the discharge. It varies in most rivers from year to year and even from day to day. If each river had a constant discharge things would be very easy for the engineer indeed. Unfortunately, they have not, and it is here that the blame for most of the failures can be laid.

If daily gaugings of the stream are known over a term of years, they form the very best kind of information on the discharge. From them hydrographs may be plotted. Horizontally the twelve months may be shown and vertically may be shown the discharge in cubic feet per second per square mile of drainage area. By changing the scale, we may also get the discharge in cubic feet per second and the horse power. If a hydrograph like this is available for one part of a river, it may be applied to other parts of the same river by changing the vertical scale. If the area of watershed above the point where the hydrograph is known is "x" square miles, and a hydrograph is required at a point above which the drainage area is "y" square miles, the scale is simply multiplied by $\frac{\text{"y"}}{\text{x}}$. These comparisons, however, hold good only if the conditions are similar at the various points compared.

If hydrographs are available, the engineer need not consider the relation of rainfall to run off, speculate on the effects of the physical characteristics of the watershed, evaporation, temperature and other factors, or compare the relative flow with that of other streams.

Unfortunately, data from which hydrographs may be plotted, is almost never available, or if available, does not cover a long enough term of years to be of any great value. Therefore, it is necessary to resort to estimating.

It is often possible to completely change the aspect of the proposition by regulating the discharge of the stream. The discharge varies with the character of the country through which the river flows. In the case of a river flowing through forest country the hydrograph is much flatter than in prairie or farm land. The forest gives up the water that falls on it, very much more slowly than the prairie land. In the case of prairie land a considerable amount of rainfall runs directly into the waterways, while in bush country, the water percolates through the soil and finds its way into the rivers as sub-surface run-off. It naturally takes the water a much longer time to percolate through the top soil and run through the sub-soil to the rivers, than it does to run directly off the surface of the ground. These facts account for the very high water in the prairie rivers in the spring which usually occurs in May. It also gives the reason why the maximum high water in the bush rivers does not occur until July. There is usually another period of high water about the end of August, due to the rains in July and August. The maximum low water season is in February.

The following table gives the percolation in percentages of the rainfall:

	Percentage of percolation
Ordinary ground, bare	29%
Wheat land	25%
Ordinary soil with sod	33%
Mixed forest	74%
Spruce forest	91%

The temperature, of course, has a great deal to do with the run

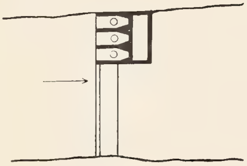

Figure 1.
Direct Developement Type

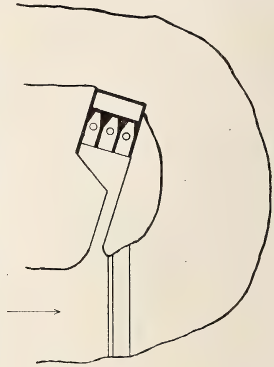

Figure 2.
Short Diversion Type

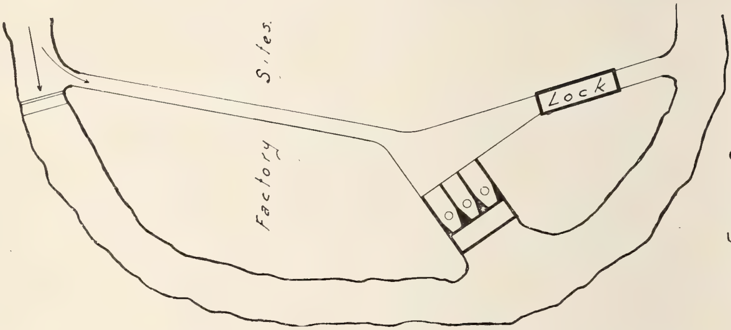

Figure 3.
Distant Diversion Type

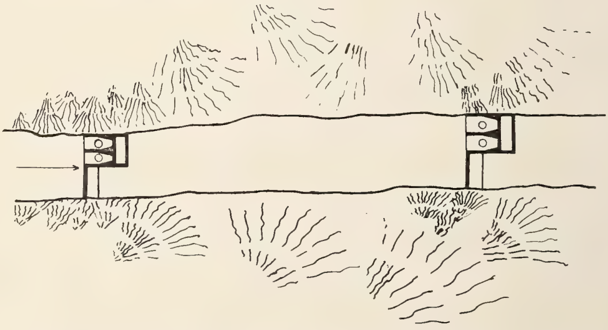

Figure 4
Divided Developement

off. In the coldest weather, most of the precipitation is frozen and retained until the warm weather comes in the spring. Thus, we have in the spring the flood time, due in part to the precipitation being retained and also to the ground being frozen, allowing the water to run directly into the rivers.

Therefore, it can be seen that a study of the physical characteristics of the watershed gives some interesting information about the steadiness of the flow, and in many cases, reforestration has been resorted to, in order to increase the steadiness. The Ontario Government, at the present time, in the laws relating to lumbering, limit the size of the tree that may be cut. This is to prevent total deforestration and preserve the rivers.

The storing facilities of the river should be looked into with a view to regulating the high and low water. Most rivers have quite large lakes at their head waters in which the high water can often be stored by putting in a small dam at the outlet. By this means the minimum flow can be increased and consequently the power. It is nearly always impossible to get the company who are developing the power to see the economy of putting in a storage system, so it is very seldom done. At the same time, in his report the engineer should mention the possibilities and cost of a storage system.

Ice is the worst enemy of the engineer in our climate, and to get rid of it, much money is spent. The top covering of ice on a river is not detrimental to power development at all. On the contrary, it is a very great help. It is the frazil and anchor ice that does all the harm. The anchor ice forms at the bottom of the river through radiation. Through a rise in temperature or other causes it is loosened from the bottom and on account of the velocity of the stream, does not get any chance to rise to the surface. The frazil ice is formed wherever there is sufficient velocity to leave open water. It forms as long needle-like crystals generally about a straw or twig is taken to the bottom of the river by eddies, and adheres to the anchor ice or is carried down by the current to still water, where it rises and adheres to the under side of the surface ice.

If great care is not taken with the head works, the frazil and anchor ice will get into the flumes and turbines in large quantities. It will cut the vanes of the turbine to pieces in a very short time.

If, in the head race, a small velocity can be obtained the very best protection against ice will be secured. On account of the small velocity the whole surface of the river will be coated with a thick covering of ice, effectually sealing it from the cold atmosphere, and the frazil and anchor formation will be reduced to a minimum. In the quiet water, the frazil ice will slowly rise and adhere to the underside of the ice sheet and thus become harmless.

If comparatively quiet water cannot be secured on the head race, mechanical means must be employed to get rid of the frazil ice. In some cases a boiler is installed and steam pipes are run to the screens to melt the ice that reaches them. Other methods of getting rid of it, in common use, are series of submerged arches, and screens. The Ontario Power Company at Niagara has very extensive head works of this nature. The water there passes into the outer forebay under submerged arches with a surface flow along the wall. From the outer forebay it passes under other submerged arches to the screens. There is surface flow along these screens to carry anything that might rise to the surface, away from them. From the screens it passes to the inner forebay and under other submerged arches to the flume. The Niagara River is, of course, unique, in that it is absolutely impossible to secure even comparatively still water near the head races.

Having gathered all the information possible the plan of development must next be considered. This is not a very difficult thing to decide as the topography of the country plainly places the development in its proper place.

The direct development (see Fig. 1) is, of course, the most efficient. In this plan the power house is placed at, or in, the dam. The head race and tail race are both very short, and consequently the losses due to friction in the races are at a minimum. Also, the plant can be operated more cheaply because it is so concentrated.

The factors which determine this choice are the relative cost of this and any other scheme, the flood flow conditions as effecting the stability of the power house, the rise in the tail race and the fluctuation in the working head. Floating timber and ice also affect the choice, as they are very dangerous to the power house, which must be protected.

The short diversion (see Fig. 2) plan is used where the dam location of the power house is not feasible, either on account of contraction of the river channel or the dam not being high enough to accommodate the machinery. By this plan the water either is carried to the power house by means of a short diversion for a head race, or is carried away from the power house by a short diverted tail race. By diversion is not necessarily meant canal. Diversion is only used to express the general idea. The water might be carried to the machinery either by a canal flume or tunnel or a combination, and away from it in the same way.

The distant diversion (see Fig. 3) program is applicable only when the concentration of the fall at one point, is impossible either on account of physical characteristics or cost. The dam is located at the best possible point and the water conducted to the power house by a flume or canal. This plan differs very little from the short diversion type but frequently offers problems not encountered in it. The plant of the Lake Superior Power Company is a well known example of this type and the canal passes through the town of Sault Ste. Marie. There are mill sites and water shipping facilities along the banks of the canal. These had to be provided for in the development scheme, as were special screens in front of the penstocks.

It sometimes happens that neither of the preceding plans are feasible. The rapids to be developed may be a mile or more long and topographical or right of way limitations prohibit them. In a case of this kind the divided (see Fig. 4) development is sometimes possible. This simply means two or more dams and power houses instead of having only the one. This plan can only be carried out when the market conditions are the best and will warrant the double operating expenses as well as the increased first cost.

It is easily obvious that each particular location is a problem in itself. The general plans, however, form a basis from which each particular plan may be selected with of course modifications to suit particular topographical or other controlling conditions.

The scope of the development must be carefully considered before the actual design is proceeded with. The total power that can be obtained at a fall or rapids may not be required for the present markets. In some cases, it may not be required for many years and to fully develop the power obtainable means tying up capital without any earning capacity.

Two courses could be followed—either to develop part of the fall or part of the flow. The government regulations now require that any company or municipality developing a portion of the power available at a fall, must have their plant so designed that any other company can develop the remaining power. This prevents any company from blanketing a fall and so designing their plant that no one else can utilize the remaining power. In view of this it is impossible to develop part of the fall. So the full fall must be used but only part of the water need be. In general, however, it is always advisable to develop the total power available, for the market can be created and the greater the output the more economical will be the unit development and operating cost.

In a few cases, the market exceeds the low water capacity before development. Then an auxiliary steam plant may be installed and the estimates for the cost of this must be provided for in the development estimate.

(*To be Continued.*)

M. E. Crouch, B.A. Sc., '11, formerly with H. J. Beatty, Pembroke, Ont., is at present engaged on re-survey work for the city of Port Arthur, Ont.

E. L. Bedard, B.A., Sc., '14, is making a survey of Stag Island, situated in the St. Clair River, six miles below Port Huron.

D. L. H. Forbes, '02, who for several years has conducted a private business as mining and metallurgical engineer, Manning Chambers, Toronto, has been appointed chief construction engineer for the Chile Exploration Co. His address is Chuquicamata (via Antofagasta), Chile, South America.

H. G. MacMurchy, B.A.Sc.,'10, is with the Dominion Power and Transmission Co., Hamilton, Ont., and not with the Toronto Power Co., as stated in the Directory last month.

H. J. MacTavish, B.A.Sc., '10, is with the street lighting department of the Toronto Hydro-Electric system. The information in the directory last month was incorrect.

C. A. Meadows, B.A.Sc., '11, has recently returned from Europe, where he has spent three months on an investigation of improved machinery for wire and ornamental iron work.

THE POWER MAN

Beyond the "utmost purple rim"
You're certain to discover him,
All khaki-clad and lean and brown
And eager for the news of town,
But having chiefly on his mind
The keen desire to seek and find
A head of water that will do
To hitch a bunch of turbines to.

You run across the "power man"
In Arkansaw or Martaban,
Or clad in true explorer's style
And seeking sources of the Nile;
His stubborn aim, his constant dream
Is hitching up some roaring stream
And getting from its rush and roar
Ten thousand horsepower—maybe more,
Where nary horsepower was before!

He's lacking somewhat in romance
A waterfall he views askance
No matter how or where it's placed
He says—"There's power gone to waste
One hundred thousand h.p. loose
Which should be put to some good use.
Not lost in spray and roar."
A torrent tumbling o'er the brim
Is wasted energy to him,
And it is nothing more.

He breaks the trail through palm and pine
For power house and railroad line,
And on his footsteps cities press
And sweep away the wilderness,
But he goes on and on and on
Toward the sunset or the dawn
With mind and heart and soul intent
On harnessing a continent,
By turning every stream he can
To power for the use of man.
One single thought is on his mind
The keen desire to seek and find
A head of water that will do
To hitch a bunch of turbines to.

By Berton Brayley, in "Power."

APPLIED SCIENCE

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EDITORIAL

We are proud to know that the "School" is well represented in the contingent which is soon to leave for Europe to engage in battle for our country's cause. No doubt a great many have gone, of whom we have not been advised. We are desirous of keeping a complete list of our men who enlist for the war and hope that our readers will notify us of any others who enlist, whose names do not appear in the personal items. The 2nd Field Company of Canadian Engineers, in which there is a University Corps is under the command of Captain T. C. Irving and Lieut. H. F. H. Hertzberg. A number of our men are with this company, while others have Commissions in the 48th Highlanders and the Queen's Own Rifles. We understand that a movement is in progress to establish University Corps with the Highlanders and Queen's Own regiments.

THE GLASGOW CORPORATION TRAMWAYS

The annual report of the Glasgow Corporation Tramways for the financial year ending May 31st, 1914, has recently come to hand, and its perusal proves quite as interesting as that of its predecessors. The estimated population served is 1,150,000, which is 2.3 times that of Toronto. Glasgow operates 194 miles of single track against 120 miles operated by the Toronto Railway Company within the limits of the City of Toronto, as of 1891. The gross capital expenditure to date on permanent way, buildings, ground and equipment is £3,675,317, equivalent to $15.50 per capita of the population served. According to the Arnold-Moyes report of a year ago, the net cost to produce new, the physical assets of The Toronto Railway Company was $13,532,992 or $27.00 per person. And had the city at that time purchased the physical and intangible assets of this corporation at the price proposed, viz., $20,608,000, the cost per capita would have been $41.

The Glasgow corporation operates 852 cars of the two-story type against 865 of all classes employed by the Toronto Railway Company. The gross traffic receipts from 336,654,000 fares were £1,078,691, giving an average fare of 1.54 cents. The fares in Glasgow, it will be recalled, vary with the distance, the smallest being 1 cent (½d.), and the largest 14 cents (7d.). The average distance the passenger may travel for 1 cent is 1 1-6 miles. Sixty-three per cent. of all fares were of this class.

The ratio of operating expenses to total receipts is 58.87% against 55%, the reported ratio for the Toronto Railway Company for the year 1912. After paying interest on investment, income tax and parliamentary expenses and providing for sinking fund and depreciation, a net balance of 4.69% of total receipts (£53,892), remains which is returned to the city under the benificent designation of "The Common Good." This amount has grown progressively from £8,260 in 1895 and aggregates for the twenty years, something in excess of $2,800,000.

Motormen and conductors are paid from 25 to 35 shillings per week.

While the average per capita expenditure for car fare in the City of Toronto is said to be about $12.00 per annum, in Glasgow it is $4.60. In other words each resident of Scotland's metropolis takes 293 car rides per year. In Toronto the number is probably slightly in excess of this. In rush hours at certain points of heavy traffic, as many as 480 cars are passed per hour. Crowding is practically unknown.

P. G.

WANTED

A man who has passed his preliminary D. L. S. examination, for eight months on D. L. S. work (day work), in Manitoba, to begin immediately.

Address communications to The Employment Bureau, Engineering Society, University of Toronto.

DODDS—RUTHERFORD

On May 6th Mr. W. A. Dodds, B.A.Sc., '09, chemical engineer for the Penman Littlehales Chemical Co., of Syracuse, N.Y., was united in marriage to Miss Laura Isabel Rutherford of Bolton, Ont., at the home of the bride's parents. Mr. and Mrs. Dodds will reside in Syracuse, N.Y.

QUAIL—CHENEY

At Port Arthur, Ont., on Monday, August 3rd, Mr. J. Quail, '09, of the engineering staff of the Manitoba Bridge and Iron Works, was married to Miss Frances Grace Cheney, second daughter of Mr. A. N. Cheney, Vanleek Hill, Ont.

GALBRAITH—HANEY

On Tuesday, July 28th, Mr. John S. Galbraith, B.A.Sc., '13, was united in marriage to Miss Aileen Haney of Port Credit, Ont. On account of the recent death of the late Dean Galbraith, the ceremony took place very quietly at the home of the bride. Mr. and Mrs. Galbraith are spending the summer with the former's mother at Go-Home, Muskoka, Ont.

GIBSON—MARSH

On Wednesday, August 26th, at the home of the bride's parents, Mr. Morton Milne Gibson, B.A.Sc., '10, of Gibson & Gibson, Ontario Land Surveyors, Toronto, was married to Miss Miriam Irene Marsh, "Elms Lea," Richmond Hill, Ont.

A large number of "School" men, we understand, have enlisted for service in the pan-European war. Among them are the following: Peter Campbell, '15; F. S. Rutherford, '14; John Kay, '14; E. S. Fowlds, '13; G. G. Blackstock, '15; B. H. Hughes, '16; F. H. Marani, '16; H. A. M. Grasset, '16; G. E. D. Greene, '09; N. Lawless, '11; C. A. Bell, '13; H. F. H. Hertzberg, '07; T. C. Irving, '06; W. M. Philp, '09-'14, W. B. Redman, '15; C. H. Mitchell and R. Y. Cory, '08.

W. W. Chadwick, B.A.Sc., '11, formerly with the Chadwick Brass Co., has now a manufacturing business at 18 Park St. S., Hamilton, Ont., where he is engaged in the manufacture of electric fixtures, fire place goods, stampings, turnings, spinnings and brass goods and metal work of every description.

J. B. Nicholson, B.A.Sc., '14, has been appointed engineer for the Township of Barton, Ontario.

R. B. Chandler, B.A.Sc., '11, formerly assistant city engineer for Saskatoon, Sask., is now resident engineer with Janse Bros., Boomer, Hughes & Crain, No. 1 Mackie Block, Calgary, Alberta, on the construction of the Government Elevator at Calgary.

IT CAN BE DONE

Somebody said that it couldn't be done,
But he, with a chuckle, replied
That "maybe it couldn't," but he would be one
Who wouldn't say so till he'd tried.
So he buckled right in, with the trace of a grin
On his face. If he worried, he hid it.
He started to sing as he tackled the thing
That couldn't be done, and he did it.

Somebody scoffed: "Oh, you'll never do that;
At least, no one ever has done it."
But he took off his coat and he took off his hat,
And the first thing we knew he'd begun it;
With the lift of his chin, and a bit of a grin,
Without any doubting or quiddit;
He started to sing as he tackled the thing
That couldn't be done, and he did it.

There are thousands to tell you it cannot be done,
There are thousands to prophesy failure;
There are thousands to point out to you, one by one,
The dangers that wait to assail you;
But just buckle in with a bit of a grin,
Then take off your coat and go to it;
Just start in to sing as you tackle the thing
That "cannot be done," and you'll do it.—Chain Belt.

C. G. Titus, B.A.Sc., '10, for three years engineer and assistant manager of the Temiskaming Mines, Cobalt, Ont., has been appointed superintendent of the Renfrew Molybdenum Mines.

W. Snaith, '07, secretary-treasurer of the Thor Iron Works, Toronto, has returned from a five months' absence in California, where he was superintending for his company the construction of a number of large oil tanks at Oldfields, Cal.

W. H. Rolls, who has for several years been sales clerk in the Engineering Society Supply Department, has left with the Mississauga Horse for the training camp at Val Cartier, Quebec, where they will continue training until they receive orders to sail for Europe to take their place in the line of battle.

M (*Continued*)

Munson, A. H., is at Walkerville as bridge inspector for the Canadian Pacific Railway.

Murdie, W. C., is with the Topographical Surveys Branch, Department of Interior, Ottawa. He is at present in North Western Ontario.

Murdock, C. R., '06. We do not know his address.

Murphy, C. J., '06, is chief engineer for the Crow's Nest Pass Coal Co., at Fernie, B.C.

Murphy, M. H., '11, has a general contracting business in Toronto.

Murray, E. W., '07, is on the engineering staff of the Department of Public Works at Regina, Sask.

Murray, J. D., '07, address not known.

Murray, W. P., '08, is with the Dominion Bridge Co., of Lachine Locks, P.Q. During the summer he has been in charge of construction work at Lytton, B.C.

Murton, J. C., '11, is superintendent for the National Paving Co. at Regina, Sask.

Mutch, D. A. S., '13, was with the Dome Mines, Porcupine, when last eard from.

N

Nash, J. C., '01, is second assistant engineer, Hamilton Hydro Electric Dept., Hamilton, Ont.

Nash, T. S., '02, is with the Topographical Surveys branch of the Department of Interior, Ottawa.

Nasmith, M. E., '08, is chemist for the Commercial Engineering Co. at Turtle Creek, N.B.

Near, W. P., '06, is city engineer for St. Catharines, Ont.

Neelands, E. V., '00, is manager of the Cobalt Comet Mine, Cobalt, Ont.

Neelands, E. W., '07, is a member of the firm Sutcliffe & Neelands, consulting engineers, surveyors, and contractors, New Liskeard, Ont.

Neelands, R. E. K., '07, address not known.

Neelands, R., '06, is on the engineering staff of the bridge department at the City Hall, Toronto.

Neilly, B., '07, is manager of the Penn-Canadian Mines, Limited, Cobalt, Ont.

Neville, E. A., '09, is a member of the firm Neville & Stewart, civil engineers, Vancouver, B.C.

Nevitt, I. H., '03, is assistant engineer for the sewage disposal plant with the main drainage department of public works, City Hall, Toronto.

New, R. H., has for his address 866 Main St. E., Hamilton, Ont.

Newhall, V. A., '10, is with the Canadian Inspection and Testing Laboratories, Ltd., Edmonton, Alta.

Newman, W., '91, has a practice as engineer and contractor, at 410 Ashdown Block, Winnipeg, Man.

Newton, J., '09, is in West Toronto at present.

Newton, W. E., '10, is with the Slocan Star Mines, Sandon, B.C.

Nichol, F. T., '10, is western representative for Clarence W. Noble, contracting structural engineer, with his headquarters at 905 Electric Railway Chambers, Winnipeg.

Nicholson, C. J., '94, is assistant engineer for the Hamilton, Guelph & Waterloo Railway, at Hamilton, Ont.

Nicklin, W. G., '05, was assistant superintendent of the Dalm & Kiefer Tanning Co., Grand Rapids, Mich., when last heard from.

Nickel, E. H., '11, is in the office of the Northern Electric & Manufacturing Co. at Winnipeg. His address is 663 William Ave., Winnipeg.

W. Noble, contracting structural engineer, with his headquarters at 905 Electric Railway Chambers, Winnipeg.

Nixon, C. K., '11, His address is 18 Washington Ave., Detroit, Mich.

Noble, E. S., '11, is with the Northern Ontario Power Co., at Cobalt, Ont.

Northey, R. K., '11. His home address is 42 Forest Hill Rd., Toronto.

Nourse, A. E., '07. We do not know his address.

O

O'Brien, E. D., '05. Address not known.

Odell, L. S., '09, is in Toronto at present.

O'Donnell, V. J., '09, was with the Canadian Westinghouse, Hamilton, when last heard from. His home is at Merrickville, Ont.

O'Flynn, W. A., '11, is with the Copper Queen Smelter, at Douglas, Arizona.

O'Grady, W. deC., '08, was engineer for the Gas Traction Co., Limited, Winnipeg, Man., when last heard from.

O'Hearn, J. J., '09, is manager of the Supply department for the Canadian General Electric Co. at their Fort William office.

Oke, W. V., '11. His address is 265 Delaware Ave., Toronto.

Oliver, E. W., '03, is assistant to the chief engineer of the Canadian Northern Ry. system, Toronto, Ont.

Oliver, J. P., '03, is superintendent of construction for the American Sugar Refining Co., Arabia, La.

O'Neil, C. M., '10, has as his home address Erindale-on-Credit, Ont.

Orr, J. A., '11. His home address is Clarkson's, Ont.

O'Sullivan, J. J., '07, is superintendent and auditor for the Canada Railway News Co.

P

Pace, J. D., '03, address not known.

Pace, G., '04, is general superintendent and engineer for the Simcoe Ry. & Power Co., Midland, Ont.

Pae, A. W., '09, is a member of the real estate firm, Davidson & Pae, Calgary, Alta.

Palmer, C. E., '10, is exchange manager for the Bell Telephone Co. at Toronto.

Pardoe, W. S., '04, is assistant professor in the department of civil engineering at the University of Pennsylvania, Philadelphia, Pa.

Paris, J., '04, has for some time been engaged as steel inspector with the T. N. O. Ry in Northern Ontario. At present his address is White Lake, Ont.

Park, D. G., '06, his address is 3031 National Ave., West Allis, Wis., U.S.A.

Parke, J., '04, address not known.

Parker, G. C., '10, is associate editor of the *Motor Magazine*, Toronto. His address is 29 Dorval Rd.

Parker, J. S., '11. His address is Burk's Falls, Ont.

Parkin, J. H., '11, is demonstrator in mechanical engineering at University of Toronto.

Parkinson, N. F., '13, is on the staff of the Ontario Board of Health at their experimental station on Clifford St., Toronto.

Parsons, J. L. R., '01, has a practice as engineer and surveyor at Regina, Sask.

Paterson, G. W., '06, address not known.

Paton, T. K., '07, address not known.

Patten, B. B., '03 and '05, is a member of the firm Rutherford & Patten, engineers and surveyors, St. Catharines, Ont.

Patton, J. McD., '11. His address is 2025 Smith St., Regina, Sask.

Patterson, J., '99, is physicist at the Dominion Observatory, Toronto, Ont.

Paulin, F. W., '07, address not known.

Peaker, W. J., '04, is with the topographical surveys branch of the Department of the Interior, Ottawa, Ont. His address is 545 MacLeod St., Ottawa.

Pearce, K. K., '10, address not known.

Pearson, A. W., '11, has Weston as his address.

Peart, J. W., '13, is in the city water commissioner's office, London, Ont.

Peckover, H. J., '08, is on the designing staff at the City Hall, Toronto, Ont. His address is 205 Dunn Ave.

Pedder, J. R., '90 (deceased).

Pepler, S. J., '11, address not known.

Pequenat, M., '08, is assistant city engineer of Berlin, Ont.

Perrin, W. J., '11. We do not know his address.

Perron, J. E., '13. address not known.

Petry, A. M., '09, is assistant manager for Chas. Potter Optical Company, 85 Yonge St., Toronto.

Pettingill, R. E., '06, is chemist in charge of plant number 8 of the Canada Cement Co., Limited, at Port Colborne, Ont.

Philip, D. H., '03, is engaged on the Georgian Bay Canal survey work at Ottawa.

Phillips, E. H., '00, is a member of the firm of Phillips, Stewart & Lee, surveyors and consulting engineers, Saskatoon, Sask.

Phillips, H. G., '08, is associated with the firm Phillips, Stewart & Lee, surveyors and consulting engineers, Saskatoon, Sask.

Phillips, C. H., '10, has 85 Manchester Place, Buffalo, as his address.

Phillips, E. P. A., '05, is a member of the firm Phillips & Benner, Ontario Land Surveyors, Ruttan Block, Port Arthur.

Phillips, J. J., '13, has been with Morrow & Beatty, of Peterboro, on the construction of paper mills at Iroquois Falls, Ont.